

USI FOUNDATION

An extension of UsiXML enabling the detailed description of users including the elderly and disabled

Nikolaos Kaklanis
CERTH-ITI



INFORMATICS & TELEMATICS INSTITUTE
Centre of Research & Technology - Hellas

Introduction

- The research community has shown interest in user modelling and user profiling over the last years.
- Many different user models have been introduced, including
 - abstract user descriptions, like Personas,
 - ontology-based user models or
 - XML-based models.
- However, there is a lack of a unified user modelling technique able to describe user characteristics in detail with focus on the elderly and disabled.
- An extension of UsiXML language is proposed, which enables the detailed description of the user, including
 - possible disabilities,
 - the affected by the disabilities tasks
 - Physical
 - Cognitive
 - behavioral/psychological user characteristics

Related work

- The notion of ontology-based user models was first developed by Razmerita et al. in 2003 that presented the OntobUM, a generic ontology-based user modelling architecture.
- GUMO has been also proposed, which seems to be the most comprehensive publicly available user modelling ontology to date.
- XML-based languages for user modelling have also been proposed. UserML has been introduced as a user model exchange language.
- There are also many existing standards related to user modelling.
 - The ETSI ES 202 746 standard specifies user preferences, including needs of people with disabilities, device related preferences and provides UML class diagrams describing the structure of the user profile.
 - ISO/IEC 24751-1:2008 provides a common framework to describe and specify learner needs and preferences on the one hand and the corresponding description of the digital learning resources on the other hand so that individual learner's preferences and needs can be matched with the appropriate user interface tools and digital learning resources.
 - ETSI EG 202 116 contains definitions of user characteristics, including sensory, physical and cognitive abilities and also describes how user abilities are changing over years.

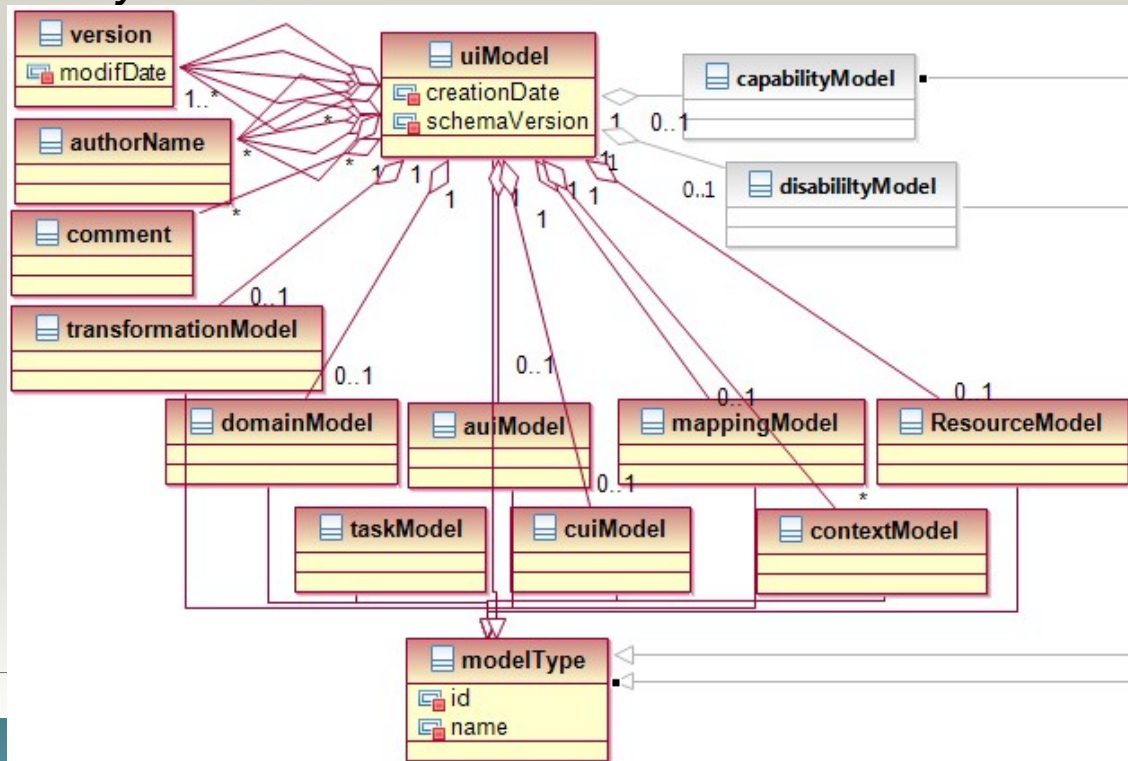
Proposed UsiXML extension

- In order to create user models that could be automatically used by software tools/modules/frameworks, the use of a machine-readable format is essential.
- The goal of the current research is to define a formal way to describe users, including elderly and people with disabilities.
- Thus, the detailed description of user's disabilities as well as the affected/problematic (due to the disabilities) tasks has to be supported.
- UsiXML has been chosen to be the basis of the proposed user modelling technique, as
 - it can sufficiently describe user tasks,
 - has some primal support for user description and
 - it is easily extensible, due to its XML nature.

Proposed UsiXML extension (2)

Two new models are introduced and added to UsiXML's *uiModel*:

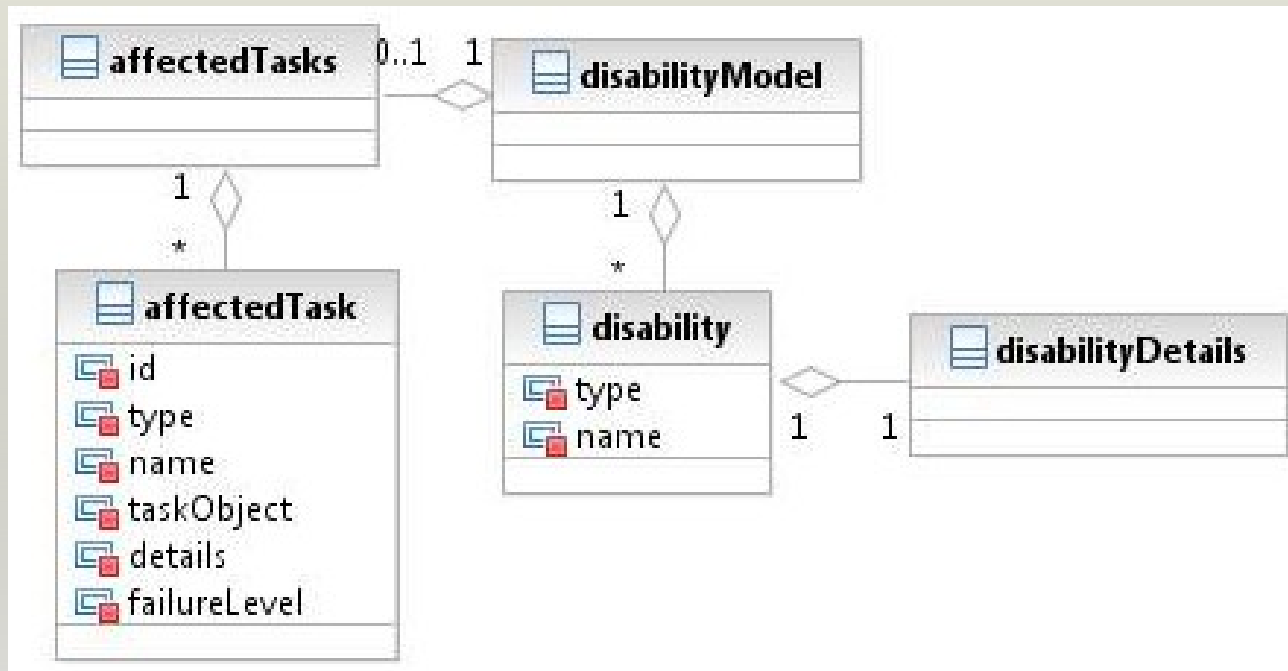
- the *disabilityModel* and
- the *capabilityModel*



Disability Model

- The *disabilityModel* describes all the possible disabilities of the user as well as the affected by the disabilities tasks.
- Each *disability* element has a name and a type (e.g. motor, visual, etc.).
- Each *affectedTask* element has the following attributes:
 - *id*: task's unique identity
 - *type*: the type of the task (e.g. motor, visual, etc.)
 - *name*: task's name
 - *taskObject* (optional): the name of the task object (e.g. "door handle" may be the task object for task "open door")
 - *details* (optional): some details/comments concerning the execution of the task
 - *failureLevel*: an indicator showing the failure level of the task due to the disabilities [accepted values: 1 to 5] – failureLevel=5 means that the user is unable to perform the specific task

Disability Model – UML class diagram



Capability Model

- The *capabilityModel* describes in detail
 - the physical,
 - cognitive and
 - the behavioral/psychological user characteristics.
- The majority of the parameters of the proposed user model concerns the physical characteristics, as most of them are measurable and independent from the environment, in contrast with the cognitive and behavioral/psychological ones.

Capability Model (2)

More specifically, the *capabilityModel* contains the following basic elements:

- a) *general*: container for some general characteristics (e.g. gender, ageGroup)
- b) *generalPreferences*: container for user's needs/preferences (e.g. preferred input/output modality, preferred sound volume, etc)
- c) *anthropometric*: container for the anthropometric data (e.g.: weight, stature, head length, sitting height, bicep breadth, etc.),
- d) *motor*: container for the motor parameters (e.g.: wrist/elbow/shoulder flexion, hip abduction, etc.),
- e) *vision*: container for the visual parameters (e.g.: visual acuity, glare sensitivity, spectral sensitivity, etc.),
- f) *hearing*: container for the hearing parameters (e.g.: resonance frequency, hearing thresholds, etc.),
- g) *speech*: container for the speech parameters (e.g.: voice pitch, fundamental frequency, syllable duration)
- h) *cognition*: container for the cognitive parameters (e.g.: memory, etc.) and
- i) *behaviour*: container for the behavioral parameters (e.g.: valence, emotional intelligence, etc.).

[illegible]

User Model example – UsiXML source code

```
<?xml version="1.0" encoding="UTF-8"?>
<uiModel xmlns="http://www.usixml.org"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-
  instance"
  xsi:schemaLocation="http://www.usixml.org/spec/UsiX
  ML-ui_model.xsd id="User_Model" name="Exported
  Virtual User Model" creationDate="2011/07/04
  13:39:51" schemaVersion="1.8.0">
  <head>
    <version modifDate="2011/07/04
    13:39:51">1.0</version>
    <authorName>Automatically generated by the
    VERITAS User Model Editor</authorName>
    <comment>This model has been generated using
    the VERITAS User Model Editor</comment>
  </head>
  <disabilityModel>
    <disability type="Motor" name="Spinal Cord
    Injury">
      <disabilityDetails>Spinal cord injury (SCI)
      refers to an injury to the spinal cord. It can
      cause myelopathy or damage to nerve roots or
      myelinated fiber tracts that carry signals to and
      from the brain. Depending on its classification and
      severity, this type of traumatic injury could also
      damage the grey matter in the central part of the
      cord, causing segmental losses of interneurons and
      motor neurons.</disabilityDetails>
    </disability>
    <affectedTasks>
      <affectedTask id="walking_ID" type="motor"
      name="walking" taskObject="" details="inability to
      effectively transfer weight between legs, abnormal
      step rhythm, excessive plantar flexion during swing
      phase, falling during activities"
      failureLevel="2" />
    </affectedTasks>
  </disabilityModel>
  <capabilityModel>
    <generalPreferences>
      <unsuitableInputModality>Undefined</unsuitableInput
      Modality>
    </generalPreferences>
    <motor>
      <upperLimb leftRight="left">
        <pullForce measureUnits="N"
        maxValue="335.0"/>
        <hand>
          <finger fingerID="thumb">
            <flexionA measureUnits="degrees"
            minValue="0.0" maxValue="35.0"/>
          </finger>
        </hand>
        <wrist>
          <radialDeviation measureUnits="degrees"
          minValue="0.0" maxValue="27.5"/>
          <ulnarDeviation measureUnits="degrees"
          minValue="0.0" maxValue="35.0"/>
        </wrist>
        <forearm>
          <pronation measureUnits="degrees"
          minValue="0.0" maxValue="85.0"/>
          <supination measureUnits="degrees"
          minValue="0.0" maxValue="85.0"/>
        </forearm>
        <elbow>
          <flexion measureUnits="degrees"
          minValue="0.0" maxValue="142.5"/>
          <hyperExtension measureUnits="degrees"
          minValue="0.0" maxValue="10.0"/>
        </elbow>
        <shoulder>
          <flexion measureUnits="degrees"
          minValue="0.0" maxValue="86.0"/>
          <extension measureUnits="degrees"
          minValue="0.0" maxValue="40.0"/>
          <abduction measureUnits="degrees"
          minValue="0.0" maxValue="21.0"/>
          <adduction measureUnits="degrees"
          minValue="0.0" maxValue="30.0"/>
        </shoulder>
      </upperLimb>
      <upperLimb leftRight="right">...</upperLimb>
      <lowerLimb leftRight="left">
        <hip>
          <abduction measureUnits="degrees"
          minValue="0.0" maxValue="37.5"/>
        </hip>
        <thigh>...</thigh>
        <knee>...</knee>
        <ankle>...</ankle>
        <footToe footToeID="1">
          <flexion measureUnits="degrees"
          minValue="0.0" maxValue="35.0"/>
          <extension measureUnits="degrees"
          minValue="0.0" maxValue="35.0"/>
        </footToe>
      </lowerLimb>
      <lowerLimb leftRight="right">...</lowerLimb>
      <neck>...</neck>
      <spinalColumn>...</spinalColumn>
      <gait>
        <stepLength>0.75</stepLength>
      </gait>
    </motor>
    <vision>
      <eye leftRight="left">
        <glareSensitivity>0.845</glareSensitivity>
      </eye>
      <eye leftRight="right">...</eye>
    </vision>
    <hearing>...</hearing>
    <speech>...</speech>
    <cognition>...</cognition>
    <behaviour>...</behaviour>
  </capabilityModel>
</uiModel>
```

```
minValue="0.0" maxValue="86.0"/>
  <extension measureUnits="degrees"
  minValue="0.0" maxValue="40.0"/>
  <abduction measureUnits="degrees"
  minValue="0.0" maxValue="21.0"/>
  <adduction measureUnits="degrees"
  minValue="0.0" maxValue="30.0"/>
  ...
</shoulder>
</upperLimb>
<upperLimb leftRight="right">...</upperLimb>
<lowerLimb leftRight="left">
  <hip>
    <abduction measureUnits="degrees"
    minValue="0.0" maxValue="37.5"/>
  </hip>
  <thigh>...</thigh>
  <knee>...</knee>
  <ankle>...</ankle>
  <footToe footToeID="1">
    <flexion measureUnits="degrees"
    minValue="0.0" maxValue="35.0"/>
    <extension measureUnits="degrees"
    minValue="0.0" maxValue="35.0"/>
  </footToe>
  ...
</lowerLimb>
<lowerLimb leftRight="right">...</lowerLimb>
<neck>...</neck>
<spinalColumn>...</spinalColumn>
<gait>
  <stepLength>0.75</stepLength>
</gait>
</motor>
<vision>
  <eye leftRight="left">
    <glareSensitivity>0.845</glareSensitivity>
  </eye>
  <eye leftRight="right">...</eye>
</vision>
<hearing>...</hearing>
<speech>...</speech>
<cognition>...</cognition>
<behaviour>...</behaviour>
</capabilityModel>
</uiModel>
```

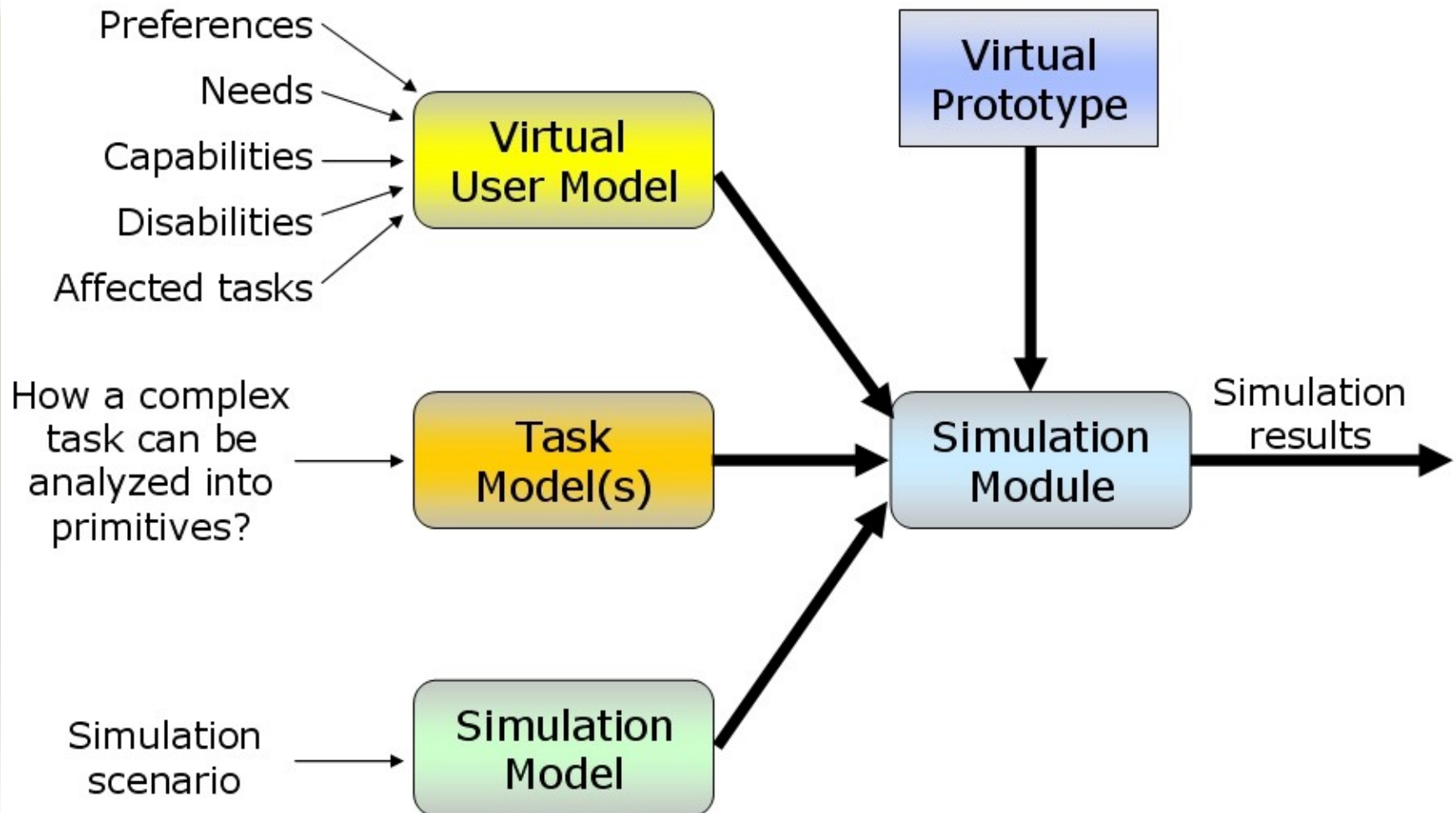
The proposed user modelling technique in practice

- A use case is presented, where the proposed user modeling technique is used. In the context of the VERITAS EU funded project (FP7 – 247765), a framework that performs automatic simulated accessibility testing of designs in virtual environments has been developed.
- The Simulation Module which is the core component of the VERITAS Simulation Framework gets as input:
 - A **Virtual User Model** expressed in UsiXML (according to the proposed extension) describing a virtual user with disabilities.
 - A **Simulation Model** expressed in UsiXML (using the *taskmodel* of UsiXML) describing the functionality of the product/service to be tested.
 - One or more **Task Models** expressed in UsiXML (using the *taskmodel* of UsiXML) describing in detail how the complex tasks (e.g. driving, computer use, etc.) are decomposed into primitive tasks (e.g. grasp, pull, etc.)
 - A **Virtual Prototype** representing the product/service to be tested.

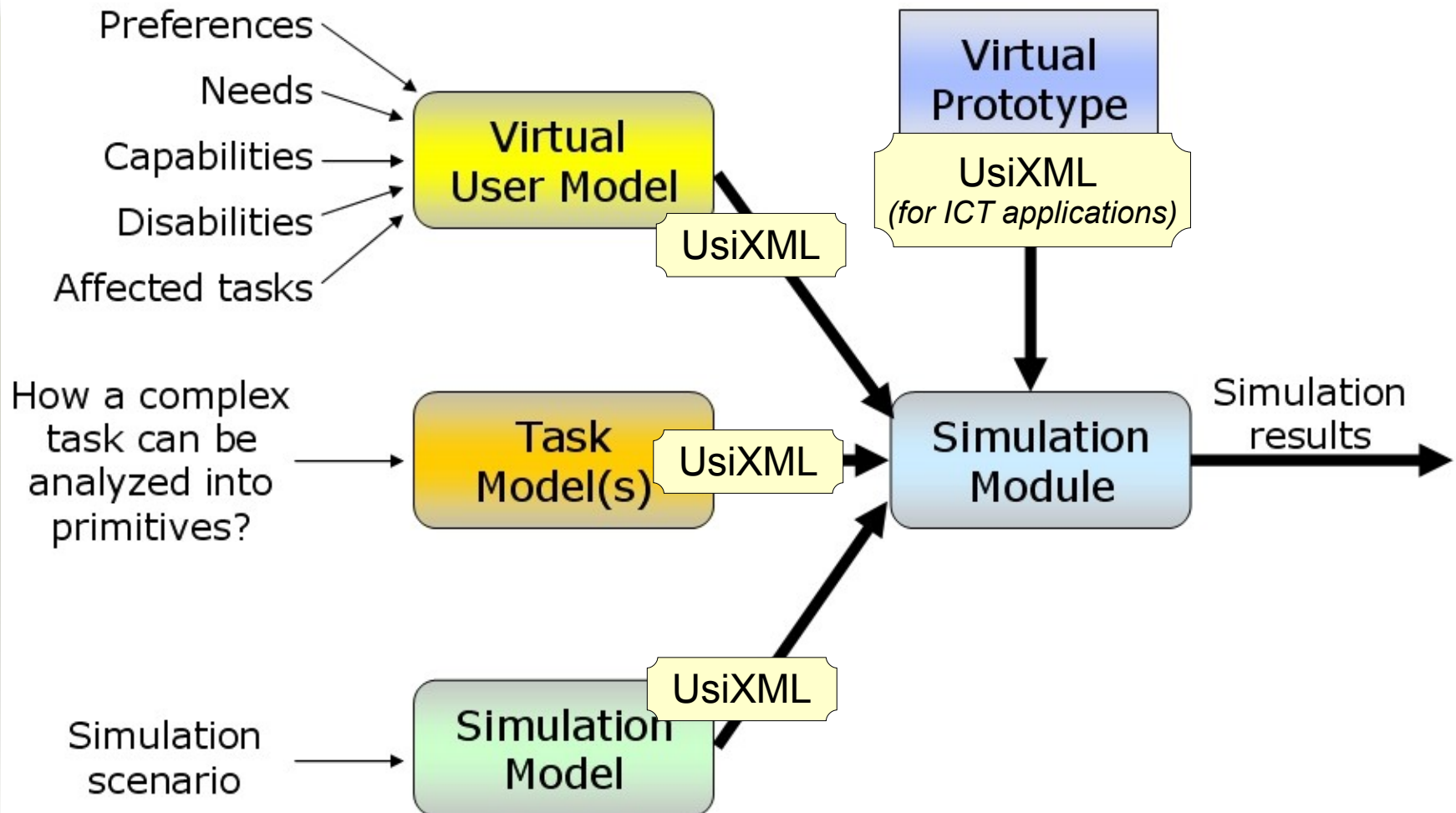
The proposed user modelling technique in practice (2)

- The Simulation Module, then, simulates the interaction of the virtual user (as it is defined in the Simulation Model) within the virtual environment. The disabled virtual user is the main “actor” of the physically-based simulation that aims to assess if the virtual user is able to accomplish all the necessary actions described in the Simulation Model, taking into account the constraints posed by the disabilities (as described in the Virtual User Model).

VERITAS Simulation framework



VERITAS Simulation framework







Virtual environment example representing a common car interior



Virtual User Models - Details

Physical characteristics	Normal Values [4][12]	Elderly (60-84) [12][25][3][26]	Spinal Cord Injury [7]
Hand maximum pull force (N)	335	76.8	
Wrist radial deviation (°)	0 – 27.5	0 – 19	
Wrist ulnar deviation (°)	0 - 35	0 – 26	
Forearm supination (°)	0 - 85	0 - 74	
Forearm pronation (°)	0 - 85	0 - 71	
Elbow hyper-extension (°)	0 - 10	0 - 4	
Shoulder flexion (°)	0 - 160		0 - 86
Shoulder abduction (°)	0 - 85	0 - 67	0 - 21
Shoulder internal rotation (°)	0 - 80	0 - 63	
Shoulder external rotation (°)	0 - 45		0 - 12
Spinal column flexion (°)	0 - 90	0 – 23.6	
Spinal column extension (°)	0 - 30	0 - 17	
Spinal column left lateral flexion (°)	0 - 25	0 - 19	
Spinal column right lateral flexion (°)	0 - 25	0 - 20	

Simulation Results

Task	Virtual User	Scenario	Simulation result	
Pull handbrake	Elderly (60-84)	Handbrake resistance (torque) : 17Nm		Failure – Reduced hand pull force
		Handbrake resistance (torque) : 6Nm		Success
Open storage compartment	Spinal Cord Injury	Storage compartment that opens by pulling a handle		Failure – Reduced range of motion
		Storage compartment without handle that opens by pushing it		Success

Conclusion

- The proposed user modeling technique enables the detailed users' description, including elderly and people with disabilities.
- The basic advantage of the proposed user models against the personas, which is probably the most popular existing technique of describing a user, is the machine-readable format.
- Additionally, the structure of the proposed user model is easily extensible by to its XML nature.
- The introduced user model is strictly correlated with user tasks. Thus, the fact that the new user modeling technique is based on UsiXML offers another advantage, as UsiXML can sufficiently describe user tasks.
- The proposed user models could be used in various simulation platforms, enabling the simulation process for virtual users with different characteristics or in adaptive user interfaces, where the user interface of an application could dynamically change in order to fulfill user's needs/preferences.